ARTIFICIAL REEFS IN DISCOVERY BAY, JAMAICA

by Michael J. Risk[1]

Introduction

Many studies have been done of artificial reefs placed in the marine environment. In some cases, the emphasis has been on augmentation of nearshore fisheries (for example, see Turner *et al.*, 1969). In other studies, the motivation has been largely to gain insight into the ecology and ethology of reef fishes (Randall, 1963; Luckhurst, 1972).

Present-day coral reefs are not only highly productive in themselves, but frequently act as a rampart or barrier, protecting coastal lagoons and bays which in turn may be highly productive (Odum, 1957). The submarine vegetation in these embayments (usually *Thalassia,* in the Caribbean) is typically under-utilized by herbivorous fishes and invertebrates due to lack of refugia from predators. Where small patch reefs occur in lagoons, they are commonly surrounded by "halos" of bare sand from which the vegetation has been completely grazed. These halos have been attributed to grazing by fishes (Randall, 1963, 1965; Luckhurst, 1972) and by sea urchins (Ogden *et al.,* 1973). The scarcity of hiding-places in lagoons is probably a result of the relative inability of corals to attach and grow on soft substrates in murky water (for a review of factors affecting corals, see Endean, 1976).

As one of the many unpleasant things which the future has in store for us is undoubtedly increasing shortages of high-protein food in Third World countries, many of which are located in or on tropical oceans, it would be valuable to investigate the possibility of utilizing more fully the vegetation in shallow coastal areas. Artificial reefs which attract fish populations may be a means of essentially converting the high-carbohydrate plant material into high-protein fish. The total productivity of the system would, of course, not be changed, but less carbon would be incorporated into the sediments.

The topography of reefs (both natural and artificial) dictates that modern high-yield fishing methods cannot be used; the common Antillean fish pot "is still the most effective way to catch bottom fish around the Caribbean" (Brownell, 1972, p. 29). Several designs

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of trap exist, of which the Jamaican "Z-trap" seems to be the most effective (Crossland, 1976). Trapping by individual local fishermen would seem, therefore, to be a reasonably efficient way of "harvesting" artificial reefs.

As a necessary preliminary, the morphology of various types of artificial reefs should be investigated, as should the relative cost (both in money and in labour) of building different types. This paper is a preliminary report on three such reefs, constructed in Discovery Bay, Jamaica, W.I.

Methods

(a) Reef construction

The artificial reefs had to fulfil two criteria: the construction materials had to be locally abundant and relatively cheap, and the finished reefs had to present a wide variety of available interstices and crevices. Therefore, the reefs were constructed out of various combinations of beach boulders and cinder blocks.

Three reefs were constructed on December 10, 11 and 12, 1973, on the east side of Discovery Bay, Jamaica (Fig. 1), equidistant from each other, in 4.3 m of water. The precise location is 100 m directly offshore from a concrete retaining wall and dock painted pink, and is marked with a small white buoy. (The author's last visit to the area was in early 1975, so both landmarks may have changed or disappeared.) The reefs are readily visible from the surface, and are located in a large *Thalassia* bed. A description of each of the three reefs follows (from south to north):

Reef One (Organized Reef) was constructed solely of concrete blocks, placed in such a way as to maximize the amount of holes and spaces available (Plates 1 and 2). Approximately 35 blocks were used in construction. The finished reef was rectangular, long dimension parallel to the shoreline, and 2.8 m long, 1.0 m wide, and 0. 7 m high.

Reef Two (Rock Reef) was constructed of subrounded boulders of Pleistocene beachrock, average diameter approximately 25 cm, placed so as to maximize the porosity. The finished reef was elongate parallel to the shoreline, 2.2 m long, 0.9 m wide, and 0.7 m high (Plate 3).

Reef Three (Veneered Reef) combined both construction materials: there was a core of beach rock, over which was placed a layer or veneer of about 15 concrete blocks. The finished reef was elongate parallel to the shoreline, 2.5 m long, 1.8 m wide, and 1.0 m high (Plate 4).

Cost of concrete blocks was $20 Canadian (1973), and total time for construction of all three reefs was two man-days' shore time (loading and transporting materials), and 6-8 man-hours' underwater labour. All rocks and blocks were placed by hand, underwater; the original research plan called for construction of a fourth reef by simply throwing beachrock overboard, but a family emergency forced the author to return to Canada before this could be accomplished.

(b) Reef monitoring

Return visits to the reefs were in late June, 1974, and late February, 1975 (or at 6- and 14-month intervals). Fishes were identified and counted on both occasions. On each visit, several censuses were taken of each reef on successive days, sometimes with two operators. Estimates of the length of the more abundant fishes were made by comparison with the length of the concrete blocks (20 cm). Fish were identified with the aid of Randall (1968), and the boring sponges were identified using Pang (1973) and Rützler (1974). Major invertebrates in and around the reefs were also identified, in some cases to major group only.

Data were supplemented with observations made by biologists working at the Discovery Bay Marine Laboratory.

Results and Observations

A summary of the fish census data is given in Table 1.

The day after construction, Reef One had attracted two fish: a small Dusky Damselfish (*Eupomacentrus fuscus*) and a Spotted Moray (*Gymnothorax moringa*). Within a few weeks, all three reefs had attracted fish, and had grown a covering of algae (Paul Sammarco, personal communication).

Two spiny lobsters were seen on Reef Three in June, 1974.

After 14 months, the reefs had attracted a wide variety of organisms other than fish, including calcareous and fleshy algae, sponges, hydroids, anemones, sabellid polychaetes, hammer oysters, arrow crabs, *Stenopus*, tunicates and urchins (*Diadema antillarum*, *Eucidaris tribuloides*, *Tripneustes ventricosa* and *Lytechinus variegatus*). In addition, the concrete blocks of Reefs One and Three supported small colonies of the corals *Porites astreoides* and *Dichocoenia stokesii*, and colonies of *Millepora alcicornis* up to 20 cm high. Coral colonies occurred on the beachrock, but much less frequently.

Both the concrete blocks and the beachrock were infested with boring algae and boring sponges (*Siphonodictyon coralliphagum*, *Cliona lampa*, *Cliona laticavola*). Infestation was highest in the beach rock; amount of material removed from the exposed outer part of some rocks was estimated to be about 8%. Some samples of beach rock contained fossil (Pleistocene) *Montastrea annularis*. Sponges boring into these fossil corals exhibit the same boring pattern as does *Cliona vermifera* in living *Montastrea annularis*: the sponge colony advances up the vacated corallite, cutting back the septa to the septathecal wall (Ward and Risk, in press). Boring pattern is evidently a response to substrate hardness.

TABLE 1. SPECIES COMPOSITION AND ABUNDANCE OF FISHES FOUND ON ARTIFICIAL REEFS IN DISCOVERY BAY.

	JUNE 1974			FEBRUARY 1975		
	Reef 1	Reef 2	Reef 3	Reef 1	Reef 2	Reef 3
Grunts (mostly *Haemulon sciurus;* some *H. flavolineatum*)	9	73	155	58	175	256
Squirrelfish (mostly *Holocentrus rutus*)	2	7	6	5	5	8
Apogon binotatus			4		4	5
Hypoplectrus puella	1	1	1	1	1	1
Amblycirrhitus pinos		1				
Priacanthus cruentatus		1	1			
Petrometopon cruentatum	3					
Pseudupeneus maculatus	2	1		1	1	1
Eupomacentrus fuscus			1	1		1
Halichoeres bivittatus		2	3	2	4	5
Halichoeres maculipinna	1				1	1
Hemipteronotus martinicensis			1			
Sparisoma rubripinne	4	2	3		2	4
Scarus croicensis	3	1	2	4	2	3
Acanthurus chirurgus	2	2	2	1	2	2
Acanthurus coeruleus				4		2
Bothus lunatus		1				
Synodus sp.			1			
Chaetodon capistratus				1	1	
Total no. species	9	11	12	10	11	13
Total no. individuals	27	92	180	78	197	290
Estimated average length of grunts (*Haemulon* sp.), cm:	12	8	4	11	8	7
Estimated average length of squirrelfish (*Holocentrus* sp.), cm:	11	9	9	12	9	10

(Fish numbers are averages of at least three separate estimates; fish lengths are averages of several hundred underwater length estimates, checked with photographs.)

Although no grazing halo was developed around any of the reefs, comparison of 6-month and 14-month bottom photographs suggests a decrease in length and density of *Thalassia* blades in the immediate vicinity of the reefs. Grazing marks were common on the concrete blocks, but not on the beachrock.

Trapping by local fishermen around the reefs began after about six months.

Discussion

Most of the fishes on the reefs were carnivores or microcarnivores, an observation made previously by Randall (1963) and Luckhurst (1972). It is likely that the reefs were exploited more for shelter from larger predators than for the fact that there is some *in situ* food production.

Reef Three (beachrock core, block veneer) supported the highest density and the largest number of species of the three reefs at both 6-month and 14-month visits. The average size of the dominant species of fish was greater on Reef One (concrete blocks), however; Reef Two (beachrock) was intermediate in all respects. Reef One had fewer nocturnal fishes, perhaps due to its open construction, and also supported more large carnivores.

The relationships among reef size, crevice size and shape, fish density and fish diversity remain obscure, due largely to the limited scope of the experiment and the short observation span. It is likely, however, that most of the fish attracted to the reefs are those which are nocturnal transients over the sand and grass flats of tropical lagoons. These fish would readily take refuge in the large cavities in the concrete blocks. The open construction of Reef One may account for the lower density of smaller fish (lack of small holes) and the larger average size. The relationship between fish populations and reef morphology has been emphasized by several authors (Bardach, 1959; Hiatt and Strasburg, 1960; Randall, 1963; Risk, 1972).

Longevity of artificial reefs also remains unknown. Rates of infestation by boring organisms seem comparable to rates observed in live corals. Undermining by *Callianassa* was also observed to cause some foundering. Bioerosion and bioturbation, therefore, would seem to set an upper limit on the age of the reefs. On the other hand, settlement and growth of corals on the reefs could prolong their life as shelters. Coral growth on artificial reefs is rarely observed (Luckhurst, 1972). Growth of corals on the reefs under discussion may be a result of relatively clear lagoon waters and a high resident diversity and density of corals (Goreau and Wells, 1967).

Artificial reefs may be constructed relatively quickly and inexpensively. Results of this study suggest only that the construction of an artifical reef affects the fishes attracted to it. Further monitoring of the reefs in Discovery Bay is necessary. It would also be important to undertake a major experiment, based on these preliminary results, using larger reefs in sets of replicates, in order to determine the degree in which fish size and species may be influenced by the type of reef construction.

The author regrets that financial restrictions terminated his site visits. Persons visiting Discovery Bay are invited to observe the reefs, as this is the only way in which further information may be obtained.

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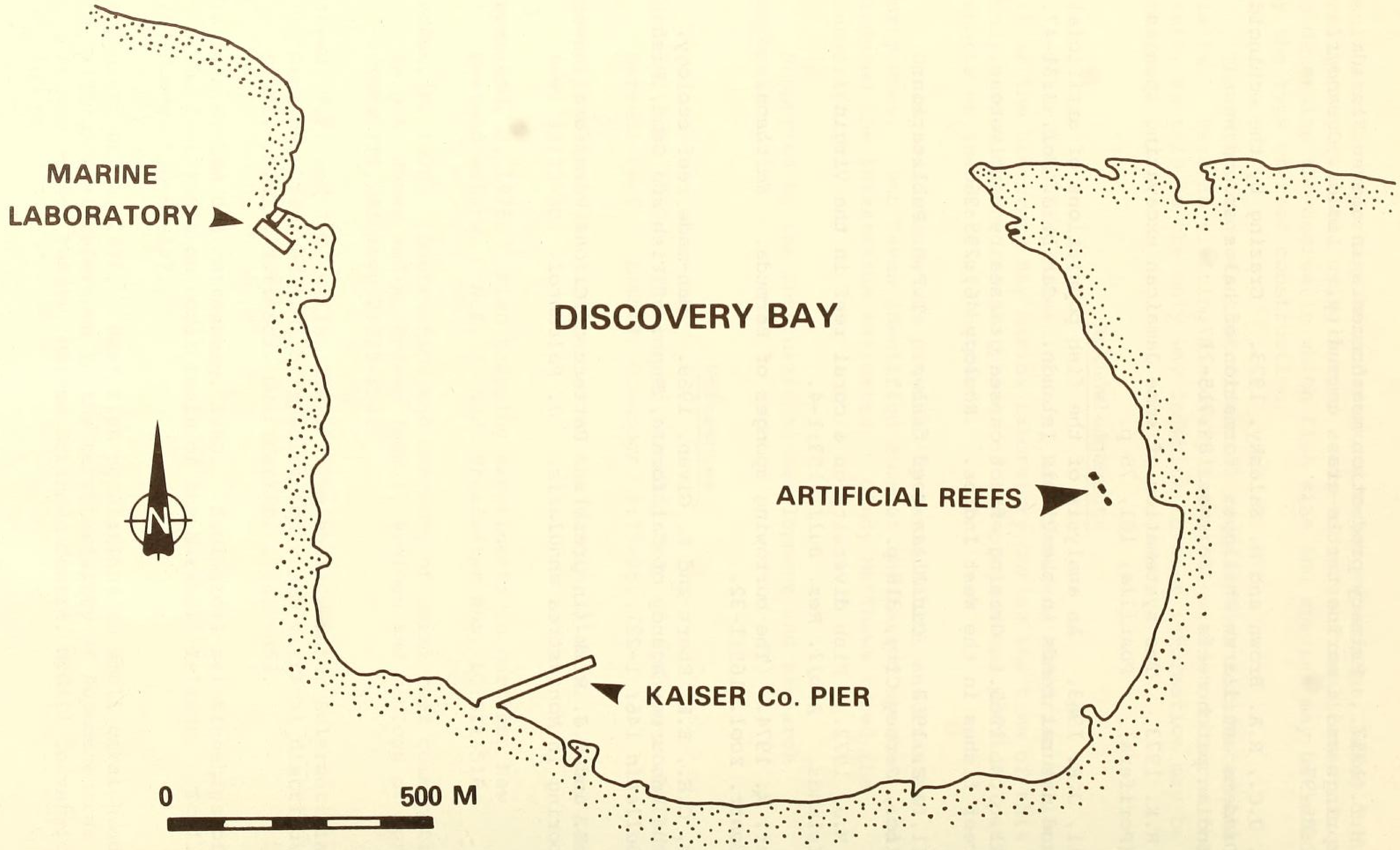

Fig. 1: Map of Discovery Bay, Jamaica, showing the location of the three artificial reefs.

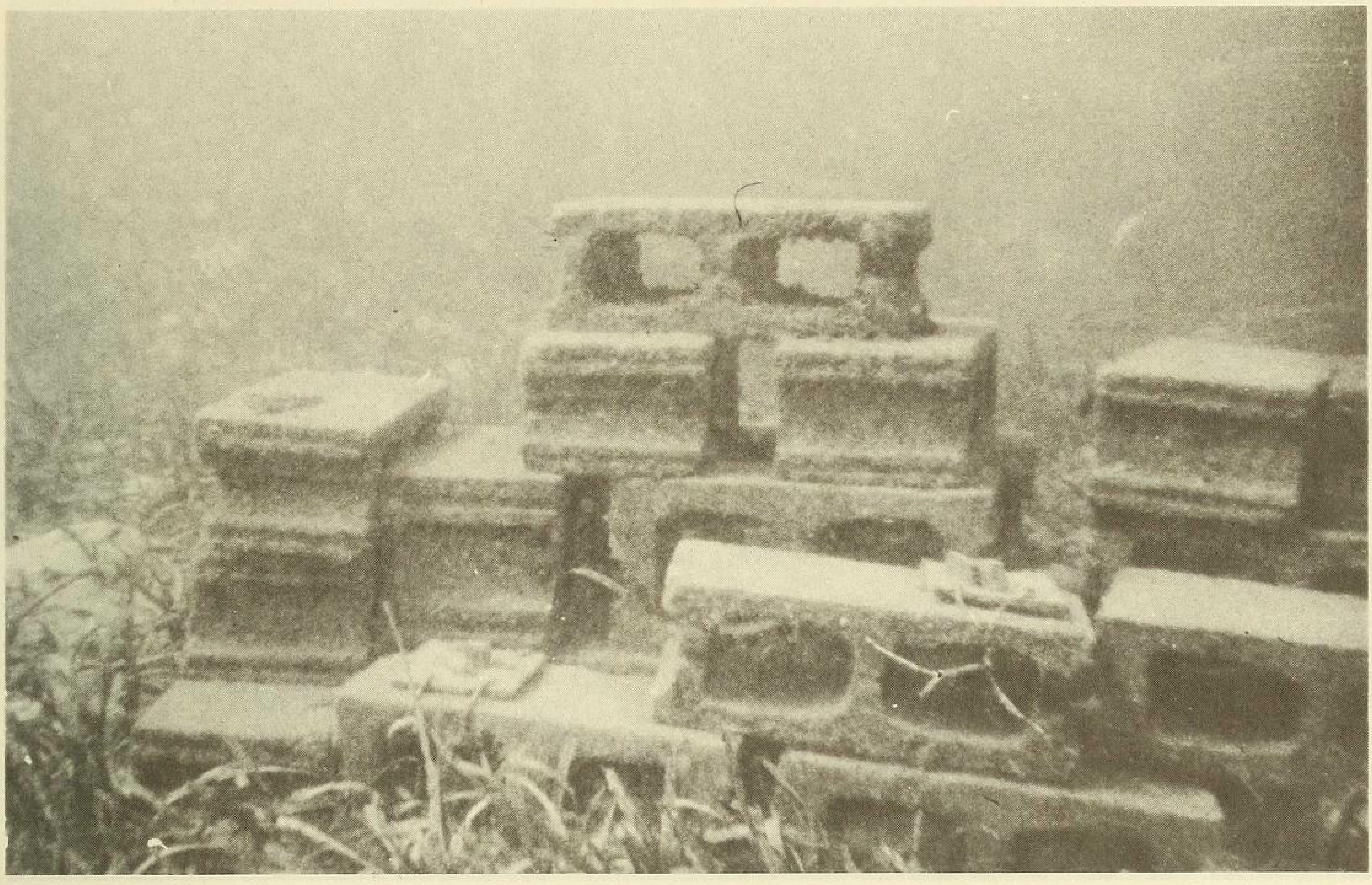

Plate 1: Reef One in June, 1974.

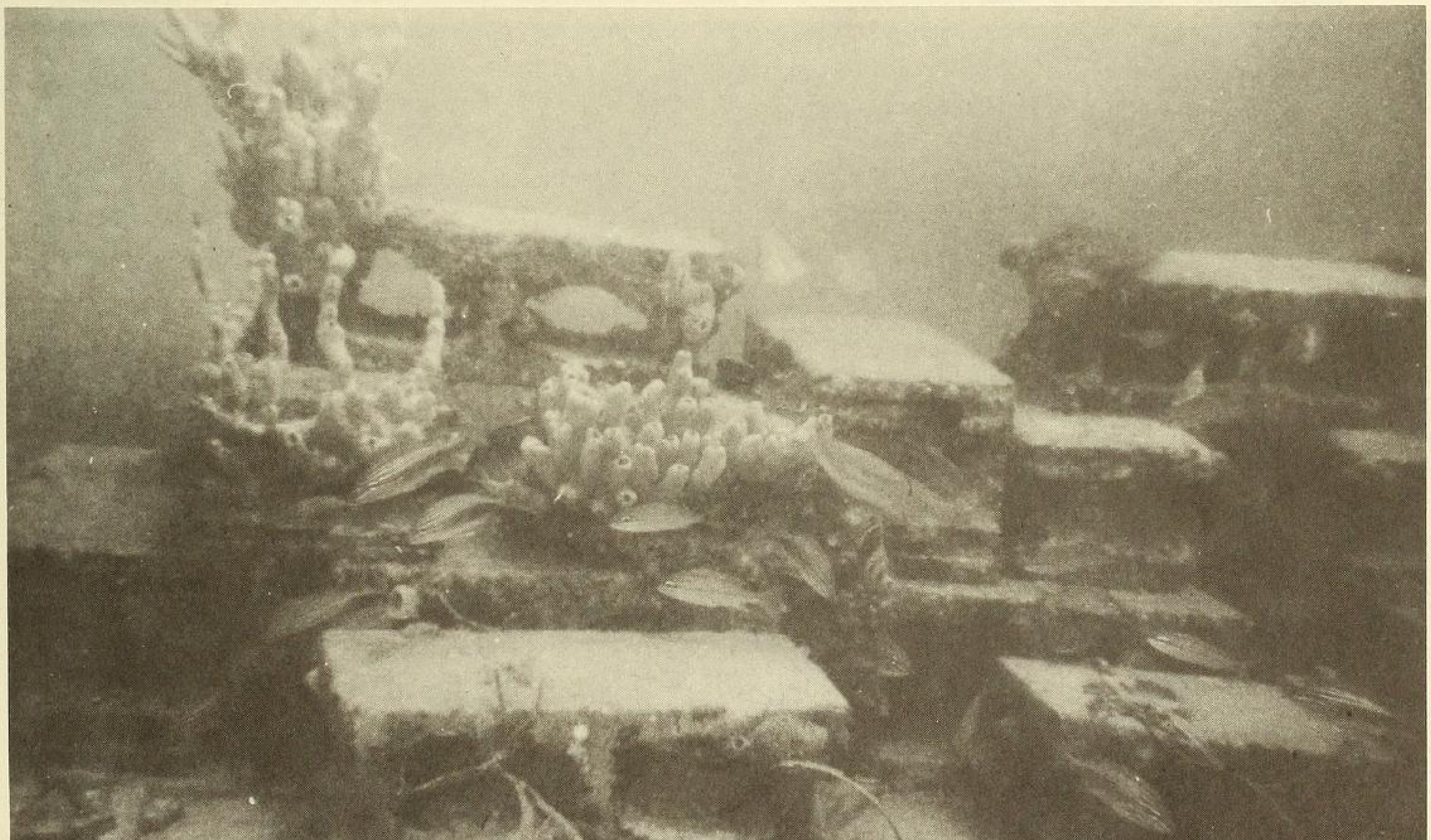

Plate 2: Reef One in February, 1975; note increase in encrusting organisms.

Plate 3: Reef Two in June, 1974.

Plate 4: Reef Three in June, 1974.